The amount of keratinized mucosa may not influence peri-implant health in compliant patients: A retrospective 5-year analysis

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Abstract: AIM (a) To investigate the influence of the keratinized mucosa (KM) on peri-implant health or disease and (b) to identify a threshold value for the width of KM for peri-implant health. MATERIALS AND METHODS The total dataset was subsampled, that is one implant was randomly chosen per patient. In 87 patients, data were extracted at baseline (prosthesis insertion) and 5 years including the width of mid-buccal KM, bleeding on probing, probing depth, plaque index and marginal bone level (MB). Spearman correlations with Holm adjustment for multiple testing were used for potential associations. RESULTS Depending on the definition of peri-implant diseases, the prevalence of peri-implantitis ranged from 9.2% (bleeding on probing threshold: <50% or 50%) to 24.1% (threshold: absence or the presence). The prevalence of peri-implant mucositis was similar, irrespective of the definition (54%-55.2%). The width of KM and parameters for peri-implant diseases demonstrated negligible (Spearman correlation coefficients: -0.2 < < 0.2). No threshold value was detected for the width of mid-buccal KM in relation to peri-implant health. CONCLUSION The width of KM around dental implants correlated to a negligible extent with parameters for peri-implant diseases. No threshold value for the width of KM to maintain peri-implant health could be identified.

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The amount of keratinized mucosa may not influence peri-implant health in compliant patients: a retrospective 5-year analysis

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Running title: Keratinized mucosa around dental implant

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Conflicts of interest

The authors declare that they have no conflicts of interest.

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Clinical Relevance

Scientific rationale for study: Conflicting results have been reported regarding the role of keratinized mucosa around dental implants, and long-term data investigating the effect of keratinized mucosa on peri-implant health is scarce.

Principal finding: The width of keratinized mucosa had a negligible correlation with parameters of peri-implant health such as marginal bone level change, bleeding on probing and probing depth. No threshold for the width of keratinized mucosa to maintain peri-implant health was identified.

Practical implication: The width of keratinized mucosa may not be crucial to maintain peri-implant health in compliant patients.

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Abstract

Aim: (i) to investigate the influence of the keratinized mucosa (KM) on peri-implant health or disease, and (ii) to identify a threshold value for the width of KM for peri-implant health.

Materials & Methods: The total dataset was subsampled, i.e. one implant was randomly chosen per patient. In 87 patients, data were extracted at baseline (prosthesis insertion) and 5 years including the width of mid-buccal KM, bleeding on probing, probing depth, plaque index and marginal bone level (MB). Spearman correlations with Holm adjustment for multiple testing were used for potential associations.

Results: Depending on the definition of peri-implant diseases, the prevalence of peri-implantitis ranged from 9.2% (BOP threshold: <50% or ≥50%) to 24.1% (threshold: absence or the presence). The prevalence of peri-implant mucositis was similar, irrespective of the definition (54% - 55.2%). The width of KM and parameters for peri-implant diseases demonstrated negligible (Spearman correlation coefficients: $-0.2 < \rho < 0.2$). No threshold value was detected for the width of mid-buccal KM in relation to peri-implant health.

Conclusion: The width of KM around dental implants correlated to a negligible extent with parameters for peri-implant diseases. No threshold value for the width of KM to maintain peri-implant health could be identified.

Keywords: dental implant, keratinized mucosa, peri-implant diseases

Introduction

Dental implants demonstrate high survival rates and thereby expanded treatment options in partially and fully edentulous patients (Blanes, R. J. et al., 2007, Derks, J. et al., 2015, Lindquist, L. W. et al., 1996, Pjetursson, B. E. et al., 2012). Apart from survival rates, clinicians and patients should be aware of biological and technical complications that occur to various extents. Peri-implant diseases are classified into peri-implant mucositits and peri-implantitis; the former affects the soft tissue only, the latter affects both, soft and hard tissues (Lang, N. P. et al., 2011, Mombelli, A. et al., 2012). Untreated peri-implant mucositis can convert into peri-implantitis at a certain time (Derks, J. and Tomasi, C., 2015). Moreover, peri-implantitis progresses in a non-linear and accelerating fashion (Derks, J. et al., 2016b, Fransson, C. et al., 2010).

Several parameters have been utilized to identify peri-implant health: probing depth, changes of the radiographically assessed marginal bone level, gingival and plaque indices, and the width of keratinized mucosa (KM). Among those parameters, the width of KM, needed to maintain peri-implant health around dental implants has been controversially discussed in the literature (Adibrad, M. et al., 2009, Bouri, A., Jr. et al., 2008, Boynuegri, D. et al., 2013, Dalago, H. R. et al., 2017, Frisch, E. et al., 2015, Schrott, A. R. et al., 2009, Souza, A. B. et al., 2016). Some studies demonstrated that an insufficient width or an absence of KM increased plaque accumulation, the gingival index, probing depth, bleeding on probing, recession, a pro-inflammatory mediator and even marginal bone loss (Adibrad, M. et al., 2009, Bouri, A., Jr. et al., 2008, Boynuegri, D. et al., 2013, Schrott, A. R. et al., 2009, Souza, A. B. et al., 2016). Other studies did not find any relationship between the width of KM and the maintenance of peri-implant health or susceptibility to peri-implant diseases (Adell, R., 1985, Dalago, H. R. et al., 2017, Frisch, E. et al., 2015, Wennstrom, J. L. et al.,

1994). Moreover, two categories of KM were defined: absence of KM (0 mm) and presence of KM (depending on the study: KM >1 or KM >2mm). The choice of a threshold value (set at 1mm or 2mm) appears to be arbitrary. No information is available in the literature supporting such a cut-off value and it is unknown whether or not such a threshold value (minimal width of KM to maintain peri-implant health) even exists.

The limitation for determining the influence of KM on peri-implant health is derived from a limited number of long-term studies and a data synthesis from a wide range of follow-up times. No consistency based on these long-term clinical studies can be found defining a threshold value or even a need from a biologic point of view for a certain width of KM (Dalago, H. R. et al., 2017, Daubert, D. M. et al., 2015, Ladwein, C. et al., 2015, Poli, P. P. et al., 2016, Renvert, S. and Quirynen, M., 2015, Roos-Jansaker, A. M. et al., 2006, Wennstrom, J. L. et al., 1994).

Thus, the aims of the present non-interventional but homogeneous study design were (i) to investigate the influence of KM on peri-implant health over time, and (ii) to identify a threshold value for the width of KM to maintain peri-implant health.

Materials and methods

Study design

The present investigation was designed as a non-interventional 5-year follow-up clinical trial based on two prospective studies with patients treated at the Clinic of Fixed and Removable Prosthodontics and Dental Material Science Center of Dental Medicine, University of Zürich, Switzerland (Ebler, S. et al., 2016, Gamper, F. B. et al., 2017) (local ethics committee numbers: 2013-0121, 2014-0201). The patients had been treated using either one of four implant systems: AST (Astra Tech Osseospeed®; ASTRA TECH implant system, DENTSPLY Implants, Mölndal, Sweden), STMBL (Straumann Bone Level Implants®; Institute Straumann AG, Basel, Switzerland), BRA (Brånemark MKIII or MKIV, Nobel Biocare, Zürich, Switzerland, STMTL (Institute Straumann AG).

Similar inclusion/exclusion criteria and protocols were applied in these studies, and described in detail previously (Ebler, S. et al., 2016, Gamper, F. B. et al., 2017). In brief, patients had to be systemically healthy and older than 18 years (of legal age). Patients had to have no local pathology, which could compromise the healing after implant surgery. Before implant placement, all patients underwent a hygiene phase and further periodontal treatment if needed. There was no restriction for the need of bone regeneration procedure (prior to or simultaneously with implant placement), and for the location of the implant (maxilla or mandible, anterior or posterior area of the jaw). All implants were placed in a prosthetically driven manner using prefabricated surgical stents. Prosthetic reconstructions were inserted by the same clinicians placing the implants. The majority of the patients received implant-supported fixed (single crown, fixed partial denture) and a few patients implant-supported removable reconstructions (removal partial denture, overdenture). The prosthetic procedures

were performed following the guidelines of each implant system. For fixed prostheses, screw-retained and cemented restoration were used on a basis of the clinical situations and clinician`s preferences. Either ball attachments or bars were designed for removal prostheses. Soft tissue augmentation was not performed between the time-point of the insertion of the final reconstruction and 5 years.

Follow-up examinations

The day of the insertion of the final prosthesis (T0) was considered as baseline. From T0, the patients were re-called at set time-points (1, 3 and 5 years). Besides these time points, the patients were individually referred to dental hygienists or regularly followed up at the Clinic of Fixed and Removable Prosthodontics and Dental Material Science Center of Dental Medicine, University of Zürich, Switzerland, depending on the attending dentists' decision and patients' wish. The data from T0 and at 5 years (T5) were used for the present analysis.

Outcome measures

Several clinical and radiographic parameters were selected for correlation with mid-buccal keratinized mucosa (buccalKM).

Clinical parameters

Clinical measurements were taken at six sites per implant (mesiobuccal, buccal, distobuccal, distolingual, lingual and mesiolingual) with a UNC-15 periodontal probe (Hu-Friedy, Chicago, IL, USA). The following parameters were assessed; (i) the width of buccalKM in mm, (ii) bleeding on probing in % (BOP) (Ainamo, J. and Bay, I., 1975), (iii) probing depth in mm (PD), (iv) plaque index in % (PI) (O'Leary, T. J. et al., 1972). For measuring mid-buccal width of KM, the peri-implant mucosa was stretched several times, thereby identifying

the mucogingival junction. All clinical measurements were supervised or conducted by a senior investigator.

Radiologic parameters

Intraoral radiographs of all implants were taken at follow-up visits (T0 and T5) using a paralleling technique with Rinn-holders and analog films (Kodak Ektaspeed Plus, Eastman Kodak Co., Rochester, NY, USA). All x-ray films were digitally scanned and the marginal bone levels were assessed at a 10x to 15x magnification using an image-analyzing software (Image J; National Institutes of Health, Bethesda, MD, USA). Before measurement, the inspectors were calibrated using randomly chosen sample under the supervision of a senior investigator. Using the distance between the threads of the implant, the marginal bone level (MB) was calculated at both the mesial and distal surfaces and mean values calculated. The reference levels for measuring marginal bone level were the borderline between the rough and smooth surface for STMTL (excluding the height of smooth collar), the flat top for BRA, and the implant shoulder for AST and STMBL.

Definition of peri-implant health and diseases

The present study used two thresholds of BOP for the definition of peri-implant diseases: (i) peri-implant health: absence of BOP/suppuration or BOP < 50%, (ii) peri-implant mucositis: BOP/suppuration or BOP≥50% with no detectable bone loss (≤0.5 mm), and (iii) peri-implantitis: BOP/suppuration or BOP≥50% with detectable bone loss (>0.5 mm).

Statistics

Implants with complete observations for peri-implant health parameters (buccalKM, BOP, PI, PD and MB) were included, and one implant per patient was chosen randomly in order to

obtain independent observations. Spearman rank correlations ρ were calculated between buccalKM, MB (each at baseline and after 5 years), PD, BOP and PI (each at 5 years) and MB change. The sample size of 87 has 80 % power in detecting even a weak correlation of ρ = 0.3 as significant ($p<0.05$). The obtained significance values were subsequently corrected for multiple testing according to Holm. All data analyses and plots were done with the statistical software R (RCoreTeam, 2016), including the packages ggplot2 (Wickham, H., 2009) and psych (Revelle, W. R., 2017).

Results

At baseline, 124 patients (63 females and 61 males) with a mean age of 54.1±13.4 (range: 20.6-77.1), having received 250 implants (55 AST, 86 BRA, 65 STMTL, and 44 STMBL) were examined. At the 5-year follow-up, 113 patients (232 implants; 48 AST, 78 BRA, 65 STMTL, and 41 STMBL) were available for re-examination. Two patients (3 implants) in AST, 3 patients (4 implants) in BRA, 3 patients (3 implants) in STMBL did not complete the 5-year examination, due to moving away or refusal to attend the follow-up. In two additional patients, 4 implants were excluded due to a lack of documentation.

In the original dataset, implants without complete recordings of buccalKM, BOP, PD, PI and radiographs (MB) at both time-points (T0 and T5) were excluded from the analysis. Subsequently, one implant per each patient was randomly selected to obtain independent observations. Finally, 87 patients (42 females and 45 males) with 87 implants and a mean age of 54.0±13.2 (range: 23.0-77.0) were included. The randomly selected implants consisted of 29 AST, 16 BRA, 14 STMTL, and 28 STMBL.

Baseline status (T0)

The mid-buccal width of buccalKM ranged from 0 to 6 mm (mean ± SD: 2.8 ± 1.4 mm). Mean PD and BOP were 3.0 ± 0.6 mm (range: 1.5–4.2 mm) and 23.0 ± 20.9% (range: 0–75%). Mean PI was 8.6 ± 18.6% (range: 0–100%). The mean MB amounted to 0.4 ± 0.6 mm (range: -1.1–3.1 mm) (Table 1).

5-year follow-up (T5)

The mid-buccal width of buccalKM ranged from 0 to 6 mm (mean ± SD: 2.5 ± 1.4 mm). Mean PD and BOP were 3.4 ± 0.8 mm (range: 2.0–6.7 mm) and 29.4 ± 25.1% (range: 0–

100 %). The mean PI amounted to 15.2 ± 24.5% (range: 0–100%). The mean MB was 0.5 ± 0.8 mm (range: -1.7–4.0 mm) (Table 1).

Changes between T0 and T5

During the 5-year follow-up, the mid-buccal width of buccalKM decreased by 0.3 ± 1.1 mm (range: -4.0–2.0 mm). PD increased by 0.5 ± 0.9 mm (range: -1.5–3.7 mm), whereas BOP increased slightly by 6.4 ± 32.3% (range: -58–83%). PI values demonstrated an increase of 6.6 ± 26.4% (-75–100%), whereas the mean MB decreased by 0.1 ± 0.6 mm (range: -2.1–2.1 mm) (Table 1).

Prevalence of peri-implant health and disease at 5 years

Depending on the threshold of BOP, the prevalence of peri-implant diseases varied. The prevalence of peri-implant mucositis on the implant- and patient-level was 42.1% and 55.2% (threshold: absence or the presence) and 42.7% and 54% (threshold: <50% or ≥50%). The prevalence of peri-implantitis on the implant- and patient-level was 32.3% and 24.1% (threshold: absence or the presence), and 15.9% and 9.2% (threshold: <50% or ≥50%).

Correlation analysis of buccalKM and parameters for peri-implant health and disease at baseline and at 5 years

The mid-buccal width of buccalKM at baseline and at 5 years was moderately correlated (Spearman correlation coefficient $\rho = 0.68$, $p<0.001$) (Fig .1). The correlation between buccalKM at baseline or 5 years and other parameters (MB at baseline, and MB, PD, BOP and PI at 5 years, as well as MB change between baseline and 5 years) was weak (between buccalKM and MB at 5 years, $\rho = -0.20$, $p = 1.0$) or negligible (between buccalKM and the other parameters matches, $-0.18 < \rho < 0.13$, $p=1.0$) (Fig. 2).

Threshold value for KM

None of the above-mentioned parameters, such as MB change, and BOP, PD and PI demonstrated any conspicuous pattern in relation to the width of buccalKM. In Figure 2, randomly distributed values of these parameters were observed, indicating that the use of specific thresholds may not be meaningful.

Discussion

The present 5-year non-interventional study demonstrated a negligible correlation between the width of buccalKM (at baseline and at 5 years) and parameters for peri-implant diseases (such as MB change, and BOP and PD at 5 years). Therefore, based on the present patient cohort in a 5-year continuous maintenance program, no threshold value for the width of buccalKM seems detectable for peri-implant health or higher susceptibility to peri-implant diseases.

Correlation between buccalKM and parameters for peri-implant health/diseases

Scientific evidence suggested that the keratinized gingival tissue is not essential to maintain periodontal health (Lindhe, J. and Nyman, S., 1980, Wennstrom, J., 1983, Wennstrom, J. and Lindhe, J., 1983a, b, Wennstrom, J. L., 1987). A series of preclinical studies using canine models demonstrated that periodontal health could be maintained without gingival recession or attachment loss, irrespective of the presence or absence of keratinized tissue (Wennstrom, J., 1983, Wennstrom, J. and Lindhe, J., 1983a, b). Moreover, in a number of long-term clinical studies, an insufficient zone of keratinized tissue did not deteriorate periodontal health (Lindhe, J. and Nyman, S., 1980, Wennstrom, J. L., 1987).

However, the necessity of KM around dental implants is controversially discussed, possibly due to differences in terms of anatomy and the susceptibility to bacterial infection between the peri-implant and the periodontal tissue (Berglundh, T. et al., 1992, Lindhe, J. and Berglundh, T., 1998). The KM around implants may be advantageous for plaque control, but it is unclear whether or not the width of KM affects the maintenance of peri-implant health (Adell, R., 1985, Bouri, A., Jr. et al., 2008, Boynuegri, D. et al., 2013, Schrott, A. R. et al., 2009, Souza, A. B. et al., 2016, Wennstrom, J. L. et al., 1994). Furthermore, different

threshold values were used (>0, >1 or >2mm) to define an adequate or sufficient width of KM (Chiu, Y. W. et al., 2015) even though these thresholds seem to be chosen arbitrarily. Nonetheless, various procedures are performed to increase the width of KM (Lim, H. C. et al., 2018, Lorenzo, R. et al., 2012, McGuire, M. K. and Scheyer, E. T., 2010, Thoma, D. S. et al., 2014). A recent systematic review based on four prospective clinical studies demonstrated favorable GI, BOP, PD and PI values as a result of soft tissue grafting to increase the width of KM (Thoma, D. S. et al., 2018). The outcomes of that review are to some extent limited by the lack of a negative control group (no surgical intervention group) (Basegmez, C. et al., 2012, Lorenzo, R. et al., 2012) and short-term follow-up periods (up to 12 months) (Basegmez, C. et al., 2012, Buyukozdemir Askin, S. et al., 2015, Lorenzo, R. et al., 2012).

In the present study, the extracted data particularly focused on potential parameters to assess peri-implant health/diseases. Based on the included 85 patients, the degree of the association between the width of buccalKM and other parameters (MB change, and BOP, PD and PI at 5 years) was negligible (Spearman correlation: $-0.11 < \rho < 0.05$) and statistically not significant. Moreover, none of the mentioned parameters showed any conspicuous pattern in relation to the width of buccalKM (Fig. 2), indicating that the use of specific thresholds may not be meaningful. These results are in line with a retrospective study performed in private practice for patients under supportive post-implant maintenance program (Frisch, E. et al., 2015). In that study, the presence or absence of KM was not associated with PD, PI, peri-implant mucositis and peri-implantitis in 10-year follow-up. This is further supported by a long-term prospective study comparing sites without KM and sites that received a free gingival graft (Roccuzzo, M. et al., 2016). Similarly, no differences in terms of peri-implant health were found between the grafted and the maintenance group even though soft tissue grafting improved the soreness during oral hygiene practice. Moreover, this unclear association was

manifested in the very recent proceeding of the world workshop held in Chicago in 2017 (Araujo, M. G. and Lindhe, J., 2018, Heitz-Mayfield, L. J. A. and Salvi, G. E., 2018, Schwarz, F. et al., 2018).

An increase in plaque accumulation (PI) was reported to be associated with a lack of KM possibly due to soreness or difficulty during oral hygiene practice (Souza, A. B. et al., 2016), thereby indicating that this parameter should be evaluated concomitantly with patient reported outcome measures. Moreover, an increase in gingival inflammation (gingival index, BOP) and/or PD values may be a reflection of the nature of the scar-like peri-implant tissue (Coli, P. et al., 2017) or of the implant sink depth, irrespective of the width of KM. Some clinical data reported a significant increase of bone loss with an insufficient width of KM (Bouri, A., Jr. et al., 2008, Kim, B. S. et al., 2009). One has to bear in mind, however, that in these studies, baseline values for marginal bone levels were at implant placement. Any initial remodeling processes due to the surgical intervention and the implant design were therefore part of the observed bone level changes. It appears to be more appropriate to prospectively evaluate the association between KM and peri-implant parameters with a baseline examination set after crown insertion to reduce the number of confounding factors (e.g. remodeling processes after implant placement).

Prevalence of peri-implant diseases

The definition of peri-implant health and diseases requires data on BOP/suppuration and bone loss assessed by radiographs (Derks, J. et al., 2016a, Jepsen, S. et al., 2015). There are some considerations for interpreting BOP and radiologic bone loss. Clinically, it can be assumed that in some cases BOP is derived from an inappropriate angulation and the force of the probe (Lang, N. P. et al., 1990), i.e. non-specific bleeding dot (Renvert, S. et al., 2018).

This may be more explicit at implant sites compared to tooth sites due to anatomical differences in the supracrestal soft tissue (Berglundh, T. and Lindhe, J., 1996) and a more pronounced emergency profile of implant prostheses. Considering this, the present study used two thresholds for BOP: i) the absence or presence of BOP and ii) BOP<50% or BOP≥50%. Interestingly, a similar prevalence of peri-implant mucositis was observed irrespective of the definitions of BOP, but a varying prevalence of peri-implantitis was observed depending on the definitions of BOP. This observation can be explained as follows: i) One or two bleeding spots by probing may be derived from traumatic probing in an everyday clinical setting. There may be a higher chance to detect peri-implant inflammation even from a single bleeding spot in a controlled clinical trial at a university setting due to an examiner calibration, and ii) the severitiy of mucosal inflammation varies despite the presence of bone loss.

In terms of radiographic bone loss, different threshold values were proposed depending on the presence of a baseline radiograph. When a baseline radiograph was present, bone loss exceeding the measurement error (> 0.5 mm) was regarded as a criterion for peri-implantitis. However, in the absence of a baseline radiograph, a marginal bone level of > 2 mm from a reference point was regarded as a criterion for peri-implantitis (Derks, J. et al., 2016a). In the dataset of the present study, all implants had baseline radiographs, leading to the use of a threshold value of > 0.5 mm.

Limitation of the present study

One of the limitations of the present study is the relatively small number of the patients included in the analysis (n=87). However, the chosen sample size is sufficiently large to have 80 % power in detecting even a weak correlation of $\rho = 0.3$ as significant ($p<0.05$). Given the

observed data pattern (Fig. 2), it seems implausible that a larger sample size would have led to the discovery of significant or clinically relevant relationships between the investigated parameters because virtually no relationships are evident.

Second, the strict maintenance care program for all included patients could have influenced the outcomes. All patients were provided individually designed maintenance schedules and follow-up visits. This should be considered when interpreting the results of the present study. Interestingly enough, in some of the previously mentioned studies, no details are given on the maintenance program (Bouri, A., Jr. et al., 2008, Boynuegri, D. et al., 2013, Kim, B. S. et al., 2009, Ladwein, C. et al., 2015, Schrott, A. R. et al., 2009, Souza, A. B. et al., 2016, Zigdon, H. and Machtei, E. E., 2008). Two studies (conducted in the private practices) reporting similar results to the present study, described their maintenance programs as "a 3-month recall interval" (Frisch, E. et al., 2015) and "an individually tailored maintenance care program" (Roccuzzo, M. et al., 2016). The relationship between the maintenance program (compliers vs. irregular compliers), the width of KM and parameters assessing peri-implant health has recently been addressed in two further studies (Monje, A. and Blasi, G., 2018, Romanos, G. et al., 2015). In a study with erratic maintenance compliers, increased probing depth values, a higher sulcus bleeding index, a higher plaque index, more marginal bone loss and more brushing discomfort were observed at implant sites with KM < 2 mm compared to implant sites with KM ≥ 2 mm (Monje, A. and Blasi, G., 2018). In the second study, an increased papillary bleeding index and a higher plaque index were reported in case the width of KM was < 2 mm compared to sites with ≥ 2 mm for patients with an irregular maintenance recall (Romanos, G. et al., 2015).

Third, the influence of the width of KM on patients' oral hygiene practice could not be evaluated due to a lack of documentation on patient reported outcome measures. Lastly, the

present study encompassed various types of reconstruction, such as single crowns, splinted single crowns, fixed dental prostheses and implant-supported cantilever fixed dental prostheses. Such might be considered as a limitation even though this variety of reconstructions represented daily business.

Conclusions

The present 5-year non-interventional study indicated that the width of keratinized mucosa around dental implants had no correlation with marginal bone level change, bleeding on probing and probing depth in compliant patients. Thus, no threshold value could be observed.

Figure legends

Figure 1 Correlation between the width of mid-buccal keratinized mucosa at baseline and at 5 years. Moderate correlation was revealed (Spearman correlation coefficient ρ= 0.68, $p<0.001$).

Figure 2. Correlation between the width of mid-buccal keratinized mucosa at baseline and the other parameters. (A) between mid-buccal keratinized mucosa and bleeding on probing (BOP) (Spearman correlation coefficient ρ= 0.0463, $p=0.67$), (B) between mid-buccal keratinized mucosa and marginal bone level change (MB change) (Spearman correlation coefficient ρ= -0.0911, $p=0.40$), (C) between mid-buccal keratinized mucosa and marginal bone level (MB) at 5 years (Spearman correlation coefficient ρ= -0.118, $p=1.0$), (D) between mid-buccal keratinized mucosa and probing depth (PD) (Spearman correlation coefficient ρ= -0.0773, $p=1.0$), (E) between mid-buccal keratinized mucosa and plaque index at 5 years (PI) (Spearman correlation coefficient ρ= -0.0897, $p=1.0$). The correlation between mid-buccal keratinized mucosa and MB at 5 years was weak, and the correlations between mid-buccal keratinized mucosa and BOP, PD, PI at 5 years as well as MB change were negligible.

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